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Negative film: automatic electronic grading

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NEGATIVE FILM: AUTOMATIC ELECTRONIC GRADING

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Summary

This report describes an automatic electronic colour-balance and exposure corrector for use with a telecine channel using negative film. Using the principle that the integral of all colours in a scene approximates to grey, and by maintaining the mean luminance at a suitable constant value, it has enabled acceptable colour television pictures to be derived from film of very variable quality.

1. Introduction

An automatic electronic colour 'grader' was required to produce, without the need for preview, transmittable colour television pictures from film which might be of inferior quality as a result, say, of incorrect exposure. (Grading is the term usually used to describe the making of suitable adjustments to a film printer to attempt to correct for errors present in the original exposure.) This equipment was envisaged as an addition to a normal telecine channel.

The use of a punched paper tape, containing predetermined correction settings for each shot, which is run in synchronism with the film would undoubtedly lead to the best reproduction of any particular film. However, for News film and much of that used in current affairs programmes there may not be time to preview the film and select the settings. Under the present arrangement for colour correction of films, an operator views the telecine output as the transmission proceeds and makes ad hoc adjustments manually and, for the one or two seconds that elapse before correction, the viewer will see significant colour errors.

This manual adjustment requires judgement and experience in deciding the corrections that must be applied to the picture, a performance which cannot be matched by simple automatic equipment. A suitable device can, however, grade the picture very much more quickly than an operator if it is given simple criteria by which to make adjustments. Nevertheless it must be remembered that, where time allows, it would be preferable to use pre-selected correction.

Despite the complicated nature of a colour television picture, it has been observed that a typical scene contains roughly equal amounts of red, green and blue information;[1] that is, the mean signal levels in the three colour channels of the telecine processor are usually approximately equal (assuming that the correct techniques were used when film was exposed in the camera). It was therefore thought that if the gains of these three channels were adjusted to make the mean signal levels exactly equal, the result would be acceptable, although not necessarily optimum for most films; further, by controlling the overall gain, some correction could perhaps also be made for incorrect exposure of the film.

The information needed to operate such a system can be obtained from a single scan of a film frame, so that, in principle, the correction could be applied completely within 20 ms. This satisfies the requirement that the automatic corrector act considerably faster than a human operator.

2. Experimental investigation

Initially a simple unit was built to measure the average colour of a picture. This unit was provided with gamma-corrected red, green and blue signals and it integrated the difference signals (G−R) and (G−B) over each field period; the output of the integrators, just before they were reset at the end of each field, were taken as measures of the mean colour deviation from grey.

At this stage it would have been possible to record this information and collect sufficient data to check the hypothesis of zero mean deviation from grey for the type of shots occurring in natural scenes. However, as this would have required the use of an ideal picture source, and posed problems concerning the subjective effects of small colour changes on a colour television picture, it was decided to aim directly at the desired objective by building apparatus which automatically adjusts the telecine channel gains so as to result in a picture with no mean deviation from grey and a constant average brightness. The quality of pictures produced by the proposed system would then be immediately available for assessment.

A negative telecine (one which scans negative film directly and performs processes corresponding to printing electronically) was used with a test sequence consisting of short extracts of typical negative film; this film was originally shot for a current affairs programme but had been rejected for programme content rather than technical reasons. The film contained typical colour casts due to failure to use the correct filter over the camera lens, under-exposure and colour casts on shots taken through windows due to partial reflections of the sky or other extraneous lighting. Although this last mentioned effect is not strictly an error, in that the camera recorded the scene objectively, the subjective effect was distracting.

Considerable improvement was effected by the automatic grader in cases where the picture would, without correction, have been poor or even untransmittable, although better results could have been obtained if an operator had controlled the channel gains manually to obtain the best picture possible. However, where the colour fidelity of the original film was good, some reduction of average quality was noticed in the automatically graded output, and the pictures derived from some scenes were clearly impaired.

Errors of grading were inevitably caused when a scene, because of its nature, did not integrate to grey. If, for example, there was a large magenta area in the picture (e.g. representing clothing) the automatic grader compensated by increasing the relative gain of the green channel and, although this may not be noticeable on the general scene content, it was detectable on flesh tones and hair included in the picture. It also desaturated the magenta area.

Other failures were concerned with the control of average luminance. In some cases a very light background caused the automatic grader to reduce the overall gain to the detriment of the darker subject material in the foreground.

Initially, unsatisfactory results were obtained from under-exposed film, since only part of its available contrast range was used and information in the low-lights that would have been recorded during a normal exposure was absent. Under-exposure also caused a reduction in the luminance of the resulting picture for which the automatic grader compensated, brightening the entire picture including its darkest areas; the lack of detail visible in the low-light areas was found to be obvious and objectionable. Once information is lost by under-exposure there is no way of retrieving it, but a considerable improvement in subjective picture quality is possible by increasing the contrast ratio so that the darkest areas of the picture are always reproduced as dark grey or black, leaving the brightest parts unchanged. A modification was therefore made to permit this whenever a large increase in gain indicated that the film had been appreciably under-exposed. After this modification the automatic grader produced acceptable pictures from under-exposed film, although the lack of low-light detail was noticeable.

3. Experimental equipment

A block diagram of the system is shown in Fig. 1. The circuit arrangements employed were straightforward, with the integrators having linear integrated-circuit operational

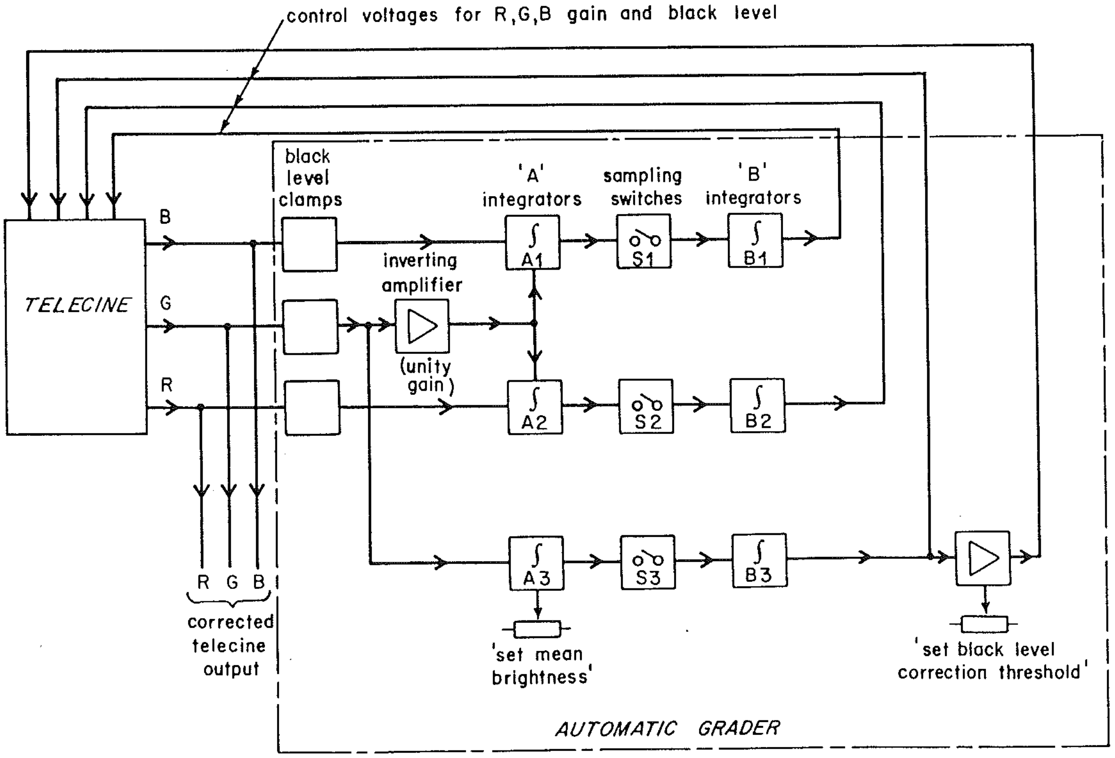

Fig. 1 - Block diagram of automatic grader, showing connections to telecine channel

amplifiers as their active devices. Junction field-effect transistors were used for the sampling switches.

A closed loop control system was used deriving its control signals from the output of the telecine channel. The black-level clamps maintained the d.c. level of the signals constant before integration.

The green channel was chosen as the master; departure from grey was measured by subtracting the green signal from each of the other two signals and integrating, and green was integrated and compared with a preset reference voltage to yield the average brightness error. Integrators B1, B2 and B3 sampled the outputs of the A integrators at the end of each field, accumulating these samples so that any residual error measured changed the corresponding B integrator output by a proportionate amount. On the next field therefore the error was reduced to a certain fraction of its former value.

Under-exposed film was detected by monitoring the naster (green) channel gain-control voltage obtained from 33. The amount of under-exposure tolerated before a olack-level adjustment was considered necessary was that vhich had restricted the information recorded on the film :o a contrast ratio of less than 100 : 1, this value being ibout the limit of performance of a high-quality picture monitor. Any increase in gain to correct for under-exposure caused the automatic grader to lower the gain-compensated black level of the telecine channel by an amount sufficient to maintain the desired contrast.

4. Conclusion

The experimental automatic grader enabled reasonably consistent colour quality to be obtained from negative films which varied widely in quality although, as expected, the quality of the pictures produced was significantly worse than that obtained by an operator using artistic judgement. Most of the output was reasonable, and all was considered transmittable, which means that, in circumstances where preview and manual adjustment of correction on the basis of an artistic judgement are not possible, automatic grading will give a significantly better average result than no correction at all.

5. Reference

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